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MATING DISRUPTION FOR MANAGEMENT OF INSECT PESTS

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INTRODUCTION

Many species of insects communicate by using a variety of chemicals. Chemical signals that elicit a response from other members of the same species are called "pheromones". "Sex pheromones" attract one sex to the other so that mating can take place and are relatively common in the insect order Lepidoptera (moths and butterflies). Sex pheromones are a complex mixture of chemicals and each species has its own specific blend. In most cases it is the female moth that emits the sex pheromones and the male that follows the pheromone trail (or plume) to find the female.

HOW DOES MATING DISRUPTION WORK?

Synthetically produced sex pheromones have been successfully used for decades to monitor insect activity patterns, and are extremely valuable tools in Integrated Pest Management (IPM) programs. Synthetically produced pheromones used in the manufacture of "lures" (for pheromone traps) are typically blends of major chemical components, along with some minor components, which attempt to mimic the effects of naturally produced pheromones. The more closely the blend matches that produced by a pheromone emitting female (known as a "calling" female), the greater the response by searching males. Mating disruption (MD) technology uses synthetically produced chemicals in large amounts to confuse males and limit their ability to locate calling females; the blends, however, are often restricted to major components released by females (since the goal is to "disrupt" rather than "attract").

There are several mechanisms that may be at work in mating disruption, each of which may vary in importance as a function of the type of dispenser being used and the insect species. The release of sufficiently large quantities of synthetic sex pheromone into the crop atmosphere interferes with mate location by:

- masking the natural pheromone plumes
- affecting the males' ability to respond to calling females
- causing the male to follow "false pheromone trails" at the expense of finding mates.

By introducing many sources of the sex pheromone into the ecosystem, the probability of the male finding the female is reduced, as is the likelihood of successful mating. As a result, mating is either delayed (with a subsequent negative affect on overall fertility) or prevented. If female moths do not mate, they cannot lay fertile eggs and, if their mating is delayed, they will lay fewer fertilized eggs in their lifetime. Consequently, the subsequent population is reduced, and fewer larvae are present to cause crop damage.

Mating disruption offers a much different approach to insect pest management than traditional insecticides. Conventional programs typically use insecticides to target the damaging life stage (in most cases, the larva). In contrast, pheromones target the reproductive life stage (the adult), thus preventing the development of the damaging life stage. Pheromones used in mating disruption are species-specific and are thus highly selective. They are generally non-toxic and will not control other pests. It is important to thoroughly understand this fundamental difference before beginning a mating disruption program.

USE OF MATING DISRUPTION PRODUCTS

Before starting to use any mating disruption products for pest management, discuss your particular situation with a qualified crop consultant experienced with MD. A site assessment to determine whether your field/orchard/vineyard is suitable for MD is a valuable first step towards success with this type of pest control product. Plan ahead

and have a season-long monitoring program personally designed before the season begins. Mating disruption can be one part of a planned IPM program agreed upon before the growing season begins. Integrated Pest Management is a decision-making process that uses all necessary techniques to suppress pests effectively, economically and in an environmentally sound manner. If you plan on monitoring your MD treated crop yourself ensure you:

- have the time for regular pest scouting
- know how to identify common insects and their damage, and
- know of any established thresholds for action if other pests become damaging.

Mating disruption works best if large areas are treated with pheromones. Ten acres is a good minimum size for a successful MD program but even larger areas are preferable. Cooperation among neighbouring farmers is probably the best way to approach an area-wide pest management program using MD. Square or rectangular blocks are best for using MD. Damage in MD blocks is typically associated with border areas (where mated females from untreated or poorly managed adjacent areas land and lay eggs). For this reason, long, narrow sites are not recommended. This technology cannot be "tried out" on a few rows or used in a small backyard planting — that is a sure path to failure with MD products.

Another important prerequisite for the successful use of MD is a low to moderate population level of the target pest. Mating disruption confuses males and makes it hard for them to find females. If the pest population in an MD site is very high to begin with, chance encounters and matings could still occur despite the use of sex pheromones. Therefore, this technology is frequently used in conjunction with insecticides. If possible, reduce populations of the pest through well timed and properly directed insecticide treatments, best management practices where appropriate, and rational cultural controls where feasible. This management can take place in years preceding the adoption of MD technology, or in addition to MD during the growing season. Once a pest population is consistently low through the combined use of cultural, insecticide and MD practices, it may be possible to manage the pest through MD and cultural controls alone.

There are two main types of MD products presently available in Ontario: hand-applied dispensers (*Figures 1, 2,* and *3*) and sprayable formulations (*Figure 4*).

FIGURE 1. Hand-applied pheromone dispenser: twist-tie type.

FIGURE 2. Twist-tie dispenser coiled on branch.

FIGURE 3. Hand-applied pheromone dispenser: clip type.

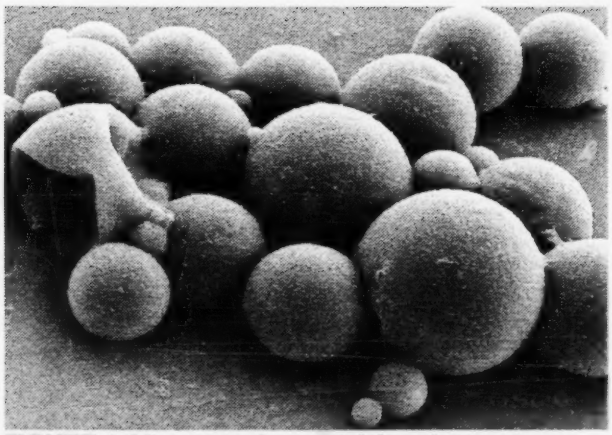

FIGURE 4. Microcapsules containing pheromone.
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HAND-APPLIED DISPENSERS

Hand-applied dispensers are or will be available in Ontario in two main forms: "twist ties" (sometimes called "tube-type") and "clips" (or "ampoules"). Different products may have very different rates of application but will always have a "per acre" or "per hectare" rate. Place dispensers in the crop individually (no bunches in one area to save time) and spread out as evenly as possible through the area to be protected. Some dispensers may indicate a different rate for block borders and some may suggest a different height for dispensers at block edges.

Hand-applied dispensers are placed throughout the orchard/vineyard/field and may or may not need to be reapplied during the season, depending on the product's lifespan and seasonal flight activity of the target pest. Different dispensers may also need to be installed at a particular height in an orchard or vineyard; consult the product labels to be sure. Some moths such as codling moth (*Cydia pomonella* (L.)) mate primarily in the tops of orchard trees. For MD to work against such pests, dispensers need to be near the top of the trees. Other moths, such as oriental fruit moth (*Grapholita molesta* (Busck)) can be disrupted fairly easily with dispensers hung in orchards at about head height or slightly higher.

Twist-tie type dispensers can be twisted onto branches in two ways; twisted over themselves or coiled around the branch (*Figures 1* and *2*). Girdling of the branch or trunk of small trees can occur occasionally if dispensers are twisted on too tightly. Always leave enough room for growth and twist the dispensers just enough to keep them from falling off. Girdling is an infrequent event but some growers may choose to remove twist ties from very young trees at the end of the season or in the spring before application of new ties. Applying the dispensers as a coil around the branch avoids the problem of girdling entirely.

Apply clip type dispensers (*Figure 3*) onto sturdy branches of 1–1.5 cm diameter. Clip dispensers placed on branches smaller than 0.5 cm may spin in high winds and work themselves off the branch. Re-hang fallen dispensers. There is some anecdotal evidence that certain species of birds (particularly crows) may occasionally investigate clip dispensers in orchards and remove them from the trees.

Most twist-tie dispensers will remain on the crop indefinitely and are difficult to distinguish from new dispensers. Do not paint dispensers or alter them in any way in order to tell them apart from older dispensers. Any alterations to dispensers can affect the rate at which pheromones are released from the dispensers and may make MD ineffective.

Workers should wear disposable latex gloves when handling dispensers. Although insect pheromones have no effect on humans, a very small percentage of people may develop a skin rash when handling large numbers of dispensers for long periods of time. Carpenter's aprons dedicated to use for each type of pheromone dispenser are useful when applying dispensers. Do not contaminate clothing by carrying bundles of dispensers in pockets. Unopened packages can be stored for use later in the year or the following year in a pesticide storage refrigerator or freezer. Opened packages can be kept for use during the season if reapplication is necessary but must be double-bagged and sealed tightly for short-term cold storage.

SPRAYABLE PHEROMONE PRODUCTS

Sprayable pheromone products are available or will be available in Ontario for MD of several pests. The pheromone blends are encapsulated in microscopic polymer capsules (*Figure 4*) and released slowly over time. Sprayable formulations currently have a shorter lifespan than hand-applied dispensers. Most sprayable pheromone products now last 2–3 weeks but longer-lived formulations will be available soon. The timing for application of sprayable pheromone products is therefore critically important (see *Monitoring* section below) as the product should be on the crop just before first flight of moths in each generation in order to keep mating from occurring.

Sprayable pheromones can be applied to orchards and vineyards with standard spray equipment. Extensive data has not been collected on compatibility of sprayable pheromones with other spray products but it does appear they are compatible with most, if not all, commonly applied insecticides and fungicides. Always check product

labels for incompatibility notices. It is preferable to apply sprayable pheromone formulations at a nozzle pressure at or below 150 psi.

In the future, sprayable pheromone formulations may be recommended in Low Rate Frequent Application (LRFA) programs. In this scenario, sprayable formulation would be applied each time another product was being used on a crop, saving growers the time and effort of applying pheromones on a particular schedule and avoiding the guesswork of anticipating each generation flight. Always check product labels for rates and frequency of application.

ADVANTAGES OF MATING DISRUPTION

Reducing pesticide use can have numerous benefits. One important benefit of using MD is in the field of resistance management. Repeated use of any one pesticide or any number of pesticides within a single chemical family can lead to populations of insect pests that are no longer controlled by those pesticides. Pesticides are valuable and important tools for modern agricultural production, so any methods to slow or eliminate the onset of resistance are beneficial. Rotation between different chemical groups or families is one effective method of preventing resistance from occurring. Decreasing the exposure of insect populations to pesticides is another method of reducing resistance. A mating disruption program can reduce the need for insecticide treatments for specific insect pests, thus reducing the pests' exposure to certain insecticides and possibly promoting the preponderance of pesticide-susceptible populations.

Insect pheromones and MD products do not have any adverse effect on humans. Thus, the use of MD is beneficial in situations where frequent travel in the crop is necessary. Mating disruption products have no or very short re-entry intervals (time after application when it is safe to re-enter the field). This can be beneficial for scheduling labour or if public entry to the field/orchard/vineyard is an issue. Pheromone products have very low or no days-to-harvest intervals (or preharvest intervals) and there are no concerns regarding pheromone residue on produce.

In cases where hand-applied pheromone dispensers and overhead irrigation are used, irrigation scheduling is simplified because there is no concern with washing the product off the crop.

For some growers, there may be a marketing advantage to reducing insecticide use. The public is encouraged to hear about instances where growers are taking a proactive approach to reducing insecticide use. If customers are interested in environmental issues, mating disruption programs may help increase sales at roadside stands and pick-your-own operations. Promoting and explaining integrated pest management (IPM) programs may also help sales.

Using MD over several years to manage a particular insect pest may help lower the local population of that pest. Reduced matings and delayed matings can lower the local population over time only if the pest is not too mobile. If the pest can travel extensively, locally lowered populations will likely be replenished from nearby sources.

Mating disruption products have a very good fit in IPM programs. They are species-specific and, for the most part, have no effect on other insect species. The compounds used are naturally occurring, generally non-toxic, and are safe to beneficials and other non-target organisms. Although the rise of secondary pests after the removal of broad-spectrum insecticides is a possibility, an equally likely scenario is that the reduction of insecticide use can lead to an increase in populations of beneficial insects, spiders and mites. An increase in beneficials can lead to further reductions in various insect pest populations in many cases.

MONITORING IN MD TREATED CROPS

Monitoring or "pest scouting" is a key component of any IPM program. Regular, competent pest monitoring allows growers to base pest management decisions on actual pest pressure rather than on inaccurate and inefficient calendar spray schedules. Using independent crop consultants and monitoring services is highly recommended for all IPM programs.

Monitoring for many types of pests (especially moth pests) is often done using pheromone-baited sticky traps. These are excellent tools for monitoring population changes such as onset of first flight and changes in pest levels through the season. However, they are not particularly good at predicting ultimate crop damage levels. Because these traps use sex pheromones to attract male moths, they are not useful for monitoring moth populations in pheromone-treated (MD) sites. Pheromone-baited sticky traps should still be used in MD sites as "sentinel traps". If the MD product is emitting sufficient pheromone to prevent the location of calling females by searching males, few males should be caught in sentinel traps. Males are sometimes trapped in sentinel traps placed at MD block borders because the level of synthetic sex pheromone in the air at these locations is often lower than within the MD block and because males may fly in from adjacent unmanaged areas, landing first in border areas.

Regular pest monitoring with sticky traps should not be done in blocks which have used MD the previous year; there may still be enough pheromone emitted from previous year's dispensers to cause trap catch reductions but not necessarily enough to prevent moths from finding mates. For some pests, including codling moth, trapping can be accomplished in MD blocks using "super lures" with 10 times the amount of pheromone normally found in standard products. The information provided by these lures can be useful in timing any required supplemental insecticide sprays where area-wide MD programs are adopted.

Monitoring in MD blocks with sentinel traps is only one part of a comprehensive monitoring program. Thorough scouting for damage caused by the pest being managed with MD is also vital. Counts of indirect and direct damage may be required. Oriental fruit moth, for example, attacks primarily shoots in the first generation, moving onto fruit in subsequent generations. Shoot "strikes" caused by first generation larvae provide an early indication of hot spots and potential failures in MD sites, where thresholds are exceeded. Similarly, checks for damage by secondary pests are critical. These should be planned before the season begins and should be performed on a regular, rational schedule. Consultants should make growers aware of thresholds for damage for the pest targeted with MD and for other pests that may be present. In some cases, if early damage assessments show that the MD program is not providing sufficient protection for the crop, growers may be able to supplement the program with recommended insecticides to reduce economic loss.

LIMITATIONS OF MATING DISRUPTION

There are some limitations to MD programs, just as there are to any pest management options. The following limitations are listed in order of probable importance for Ontario growers.

Size of area treated

The minimum suggested size for areas of MD is 2–4 ha (5–10 acres). Some product labels list 2 ha (5 acres) as the minimum size but experience with MD demonstration blocks in Niagara suggests that 4 ha (10 acres) are required to achieve success with MD. Neighbouring growers who cooperate and adopt wide area MD programs have a much better record of success with this technology. Mating disruption will not work on a few rows or on a few backyard trees.

Timing of application

One of the most frequent causes for failure of MD products to suppress mating is incorrect timing of installing dispensers or applying sprayable pheromones. Details of timing for specific pests is not listed in this general factsheet, but, as a general rule, MD products need to be on the crop before first flight of the pest species in the spring. Some programs have relied on the use of an insecticide directed at the first generation to reduce populations to a low level, with subsequent populations managed by MD (alone or with supplemental insecticides required as indicated by monitoring). There are some other restrictions and strategies depending on the particular pest and product being used so it is best to work closely with product representatives and crop consultants familiar with MD.

Shape of area treated

Mating disruption blocks should be as square as possible. Do not use this technology on long, narrow sites or a few rows of crop. Pheromones are volatile and move with airflow, so the pheromone product will not remain in sufficient quantities on narrow sites in normal wind conditions. In addition, individuals migrating from adjacent areas tend to land in border rows first. Long, narrow areas have a larger vulnerable border (relative to the total area treated) than do square blocks. Consequently, a larger portion of the crop remains at risk from migrating mated females (see *Immigration of mated female pests* section).

Initial pest population level

It is important for pest levels to be low to moderate for MD to work. High pest populations in an MD treated site can allow males and females to meet and mate by chance even in the presence of high levels of synthetic sex pheromone. In some cases, efforts must be made for several years to lower pest populations by using rotational strategies of registered insecticides and cultural controls. Pest levels are different across Ontario so consult with local crop consultants and other agricultural support personnel to devise the best strategy for lowering local populations before beginning an MD program.

Rates of mating disruption products

Use mating disruption products, like any pest control products, at the recommended label rate. Research is being carried out worldwide on the lowest rates at which various MD products are effective and information on those projects is often available before final results are obtained. Leave that research to the researchers and use MD products as directed by the label.

Immigration of mated female pests

Female pests may mate outside of MD blocks, enter the blocks and lay fertile eggs. How much this affects an MD block depends on many factors such as: how many mated females are in the vicinity of the MD block, how far they can fly, what time of year they are most active, how attractive the MD block is, how many alternate and wild

hosts the pest has, and how close the MD block is to poorly managed or abandoned orchards. Immigration of gravid (mated) females may also increase late in the season when fewer "targets" (e.g.; ripe fruit) remain. Late season varieties may be particularly vulnerable to infestation through the migration of mated females.

Many pest insects will not travel very far in their lifetime and will not leave nearby blocks if there is sufficient suitable host plant material. Some however, travel considerable distances. Monitoring MD blocks is therefore critical to ensure damage is not occurring from the offspring of immigrating pests. For cross-commodity pests such as oriental fruit moth (stone and pome fruit), seasonal management strategies may vary between crops. Growers and crop consultants must consider when the crops are harvested relative to the seasonal activity of the pest.

Discuss immigration of pests with your crop consultant for each pest and each crop where you are considering MD. Find out all you can about the biology of the pest you are trying to disrupt so you can determine whether MD is appropriate in your situation.

Internal sources of pests

Cull piles and bin piles within an orchard/vineyard/field can also lead to infestations. Overwintering survival may be greater under these conditions. Males and females emerging in bin storage piles can easily find each other by chance in spite of pheromone treatment of the surrounding area. Sanitation involving the removal and disposal of infested fruit is key to reducing internal pest populations.

Secondary pests

In some cases, insecticides targeted at major pests may control minor pests. Mating disruption programs for major pests should reduce insecticide use for control of major pests. Therefore, some minor pests may rise to damaging levels in MD blocks. It is also possible that reductions in insecticide use may allow beneficial insects and mites to thrive and provide natural biological control of minor pests.

The key to preventing economic damage from secondary pests is vigilant, regular, competent monitoring of MD areas. Monitoring provides early identification of damage from secondary pests and allows growers to take appropriate action before economic thresholds are reached. All IPM programs, including those using MD, need to be flexible to respond to the changing dynamics of pest complexes.

Size of crop plants

First year plantings of orchards are not recommended for MD. Pheromones emitted from dispensers will dissipate rapidly in situations where little foliage is present. The same is true for sprayable formulations of pheromones. However, a combination of insecticides and MD in young plantings may help lower local pest populations making MD more effective in subsequent years.

Temperature

Release of pheromones from fixed-point dispensers and from plant surfaces when sprayable formulations are used is temperature dependant. Below 10°C, little pheromone is emitted but that is not a problem as insects will be relatively inactive at low temperatures. High temperatures cause more rapid emission of pheromones from dispensers and plant surfaces. The length of life of MD products may be shortened with prolonged high temperatures. In general, this should not be a problem in Ontario summers and only becomes a concern with consistent temperatures above 30°C–35°C.

Wind and slope

Areas with consistent high winds are not suitable for MD because wind will move the pheromones away from the crop and the concentration of pheromones necessary for MD will not be maintained. Pheromones are heavier than air and can, in low wind situations, flow down steep slopes, leaving upper areas of a crop unprotected. Neither of these situations is typical for most areas in Ontario. One solution for these problems could be to increase the number of dispensers in upwind areas or on higher slopes.

SUMMARY

Mating disruption using synthetic sex pheromones is an effective and environmentally friendly way to help manage some insect pests. Pheromone-based MD products do not kill anything, not even the target pest, but can provide economic control of some pest species while reducing pesticide use. Reducing the use of insecticides can have additional benefits for pesticide resistance management and for preservation of beneficial insects, mites and spiders.

Pheromone products for MD work by making it difficult for male moths to find females for mating. If female moths do not mate, they cannot lay fertile eggs, thus reducing the number of damaging larvae within the cropping system.

Currently, MD products available are for certain moth pests and primarily for use in orchards and vineyards. Each MD product is specific for one species of pest only and has no direct effect on other insects. Mating

disruption programs do have some limitations, as do all pest control programs, and may require some specialized monitoring to ensure their success. Mating disruption programs can be extremely useful parts of IPM programs and work best in large, contiguous areas.

For a listing of recommended MD products, consult OMAF's current Publication 360 *Fruit Production Recommendations* or visit the Pest Management Regulatory Agency's Web site for a detailed accounting of all registered products.

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